TITLE: "METHOD AND APPARATUS FOR REMOVING FLUIDS FROM DRILL CUTTINGS "

CROSS REFERENCES TO RELATED APPLICATIONS: THIS IS A CONTINUATION-IN-PART OF UNITED STATES PATENT APPLICATION SERIAL NO. 10/055,561, CURRENTLY PENDING

STATEMENTS AS TO RIGHTS TO INVENTIONS MADE UNDER FEDERALLY SPONSORED RESEARCH AND DEVELOPMENT: NONE

INVENTORS: OWEN THOMAS RISHER
NOLAN JOSEPH FITCH
RONALD CHARLES LANDRY
MICHAEL DAVID BILLEAUD
DAVID JON TILLEY

BACKGROUND OF THE INVENTION

1. Field of the Invention

The present invention relates generally to the treatment of drill cuttings generated during oil and gas well drilling operations. More particularly, the present invention relates to a method and apparatus for the removal of fluids, such as drilling mud, mud additives and contaminants, from drill cuttings. More particularly still, the present invention relates to a method and apparatus for the separation of entrained and/or adherent fluids from drill cuttings, thereby permitting recovery of such fluids as well as efficient disposal of the solid components of said drill cuttings.

2. Description of the Related Art

Drilling rigs used for the drilling of oil and gas wells typically include a supportive rig floor positioned over a well, a derrick extending vertically above said rig floor, and a traveling block which can be raised and lowered within said derrick. During drilling

operations, a drill bit is generally conveyed into a well and manipulated within said well via tubular drill pipe. The drill pipe is raised and lowered within the well utilizing the drilling rig derrick.

When installing drill pipe or other tubular pipe into a well, such pipe is typically installed in a number of sections of roughly equal length called "joints". As such pipe penetrates farther and farther into a well, additional joints of pipe must be added to the ever lengthening "string" or "drill string" in the rig derrick. Thus, a typical drill string comprises a plurality of sections or joints of pipe, each of which has an internal, longitudinally extending bore. During drilling operations, a drill bit or other desired equipment is typically attached to the lower or distal end of said drill string.

During drilling operations, a fluid known as drilling mud or drilling fluid is normally pumped down the longitudinally extending bore of the tubular drill pipe, and circulated up the annular space which is formed between the external surface of said drill pipe and the internal surface of the wellbore. The basic functions of drilling mud are: (1) to cool and lubricate the drill bit and downhole equipment during drilling operations; (2) to transport pieces of drilled-up rock and other debris from the bottom of the hole to the surface; (3) to suspend such rock and debris during periods when circulation is stopped; (4) to provide hydrostatic pressure to control encountered subsurface pressures; and (5) to seal the porous rock in the well with an impermeable filter cake.

As circulated drilling mud returns to the earth's surface and is pumped out of a well, the mud often contains pieces of broken, drilled-up rock and other solid debris known as "cuttings" or "drill cuttings". In most cases, an effluent mud stream flowing out of a well, together with associated drill cuttings, is directed to one or more devices

which are specifically designed to separate such drill cuttings from the mud. Such devices include, but are not limited to, "shale shakers," desanders, desilters, hydrocyclones and centrifuges.

Shale shakers, which are well known in the art, are essentially screens that are used to separate drill cuttings from the drilling mud. In many cases, shale shakers utilize a series of screens arranged in tiered or flat disposition relative to each other. Further, such screens are often made to vibrate in order to increase the quality of such separation. The bulk drilling mud falls through the screens by gravity, while the predominantly solid cuttings pass over the end of the screens. Certain shale shakers are designed to filter coarse material from the drilling mud, while other shale shakers are designed to remove finer particles from the well drilling mud.

Shale shakers and other cuttings-removal equipment perform a valuable function in the overall drilling process. If drill cuttings are not removed from the effluent mud stream as such mud is circulated out of a well, said cuttings would remain in the active mud system. These drill cuttings and other debris would then be recirculated into the well. This often leads to problems, because such drilled solids can dramatically alter the characteristics and performance of the drilling mud. Further, recirculation of drill cuttings can also increase wear in mud pumps and other mechanical equipment used in the drilling process. As such, shale shakers and other similar devices are frequently necessary to efficiently separate drill cuttings from drilling mud as it is circulated out of a well.

Once drill cuttings and other debris have been separated from the bulk mud stream flowing out of a well, it is necessary to dispose of such cuttings. Unfortunately,

in most instances the disposal of drill cuttings can present a number of different problems. Often, the most economical way to dispose of drill cuttings would simply be to discharge said cuttings directly into the surrounding environment. However, even though drill cuttings leaving a shale shaker or other separation device may have been separated from a well's effluent mud stream, such cuttings nonetheless typically include entrained and/or adherent mud and other fluids which could be damaging to the environment.

In order for drilling mud to accomplish its intended objectives, it is often necessary to adjust or control certain characteristics of such drilling mud. Thus, chemicals and/or other additives are often mixed into such drilling muds. Common drilling mud additives include gelling agents (e.g., colloidal solids and/or emulsified liquids), weighting materials, and other chemicals which are used to maintain mud properties within desired parameters. Further, although drilling mud has historically been water-based, improved results have been obtained using oil-based or synthetic-based muds, especially in severe drilling environments. Many of these additives, oil-based muds and synthetic-based muds can be environmentally harmful. Thus, it is often undesirable and a violation of environmental regulations to release such fluid-laden cuttings directly into the surrounding environment.

In order to avoid environmental contamination and comply with applicable governmental regulations, drill cuttings are frequently transported from a drilling rig to an off-site facility for disposal. In order to accomplish such off-site disposal, drill cuttings are generally loaded into boxes or other storage containers for transportation

away from the rig. While this solution can be generally functional, it is not without significant problems.

One major problem associated with the off-site disposal of drill cuttings is increased cost. In most cases, special equipment is needed to move fluid-laden drill cuttings from a rig's shale shakers to another location on the rig where storage boxes are loaded. Such equipment is often in the form of complicated and elaborate conveyors, augers and/or vacuum units. Moreover, large numbers of storage boxes must be rented or purchased in order to accommodate such cuttings. All of this added equipment and labor increases the costs associated with the drilling process.

Another major problem associated with off-site disposal of fluids-laden drill cuttings is the use of valuable rig space. Space is at a premium on most drilling rigs, and particularly those that work in a marine environment. In most instances, cuttings disposal equipment takes up a great deal of a rig's available work area. For example, large storage boxes, which must be loaded on and off a rig, take up a significant amount of space. Similarly, equipment used to move such cuttings from a rig's shale shaker to cuttings boxes can also take up a great deal of space. This additional equipment can present logistical and/or safety problems on many rigs.

Another problem associated with off-site disposal of drill cuttings is environmental impact. Such off-site disposal of drill cuttings does not necessarily guarantee an overall reduction or elimination of environmental contamination. Cuttings boxes must be transported to a rig, loaded with cuttings, and thereafter moved to an off-site storage facility. Trucks, vessels or other pollution-emitting means of transportation

must typically be employed to transport said boxes to and from the rig. As a result, the overall impact on the environment of offsite disposal can be significant.

Attempts have been made to clean drill cuttings in order to remove surface contaminants prior to discharge of such cuttings into the environment. For example, certain cuttings recovery and treatment devices utilize separate cells having low speed agitators to stir a mixture of cuttings and cleansing surfactants. The cuttings are transferred from one cell to the next where additional agitation and cleansing takes place. Thereafter, a slurry of cleansed drill cuttings and surfactant is pumped from the cells to a vibrating screen operation in which most of the surfactant is removed and recovered for later use. In some cases, a portion of the surfactant solution, which is rich in fine drill cuttings and adherent drilling fluids, is run through one or more hydrocyclone separators which discharge the fine drill cuttings in solution separated from the larger, cleansed drill cuttings.

However, attempts at washing or otherwise treating drill cuttings on location have also proven to be problematic. Frequently, existing methods of washing drill cuttings require large amounts of equipment, which can cause space problems on most drilling rigs and add to the overall expense of a drilling project. Further, such cuttings washing systems utilize surfactants or other solutions which must be disposed of or, at a minimum, kept out of the surrounding environment. Perhaps most significantly, washed drill cuttings are seldom clean enough for discharge directly into the surrounding environment.

Accordingly, the need exists for a means to separate entrained and/or adherent fluids from fluids-laden drill cuttings. Said separation means should not take up a large

amount of space on a drilling rig and should be easily adaptable with existing rig equipment. In areas in which on-site disposal is allowed, such separation means should remove sufficient amounts of fluids from fluids-laden drill cuttings to permit disposal of the solid components of said cuttings directly into the surrounding environment. In situations in which cuttings are stored in boxes or other means of transportation for off-site disposal, said separation means should remove enough entrained and/or adherent fluid from said cuttings to reduce the overall volume of the materials, thereby reducing the amount and/or size of the boxes needed to transport a given amount of cuttings. Additionally, there is a need for a means of separation which provides for the recovery and reclamation of fluids separated from such drill cuttings, particularly oil-based or synthetic-based drilling fluids.

It is, therefore, an object of the present invention to provide a means of removing fluids, and particularly entrained and/or adherent fluids, from drill cuttings.

It is further an object of the present invention to provide a means for recovering a greater percentage of drilling mud and other fluids from drill cuttings than existing separation methods.

It is yet another object of the present invention to provide a means of separating fluids from drill cuttings which utilizes a relatively small amount of equipment and, therefore, has minimal space requirements.

It is yet another object of the present invention to provide a means of separating fluids from drill cuttings which can easily integrate with existing rig equipment.

It is yet another object of the invention to provide a means of removing entrained and/or adherent fluids in drill cuttings being transported for off-site disposal, thereby making such transport more economical.

It is yet another object of the present invention to provide a means of separating sufficient amounts of entrained and/or adherent fluids from fluids-laden cuttings to permit efficient disposal of the solid components of said cuttings.

It is yet another object of the present invention to provide a means of separating entrained and/or adherent fluids from fluids-laden drill cuttings which permits the efficient reclamation and/or reuse of such separated fluids.

SUMMARY OF THE INVENTION

The present invention provides a method and apparatus for highly effective separation of fluids, such as drilling mud, mud additives and contaminants, from the solid components of oil well drill cuttings. Further, the present invention provides a method and apparatus for recovery of such separated fluids for re-use and/or disposal. Further still, the present invention is easily adaptable with existing rig equipment, and requires significantly less space than existing devices currently used to treat fluid-laden drill cuttings, and/or to separate fluids from such drill cuttings.

In the preferred embodiment, the present invention utilizes an elongate central member. Said elongate central member can take any number of shapes or outward configurations; however, in the preferred embodiment, said elongate central member is roughly in the shape of a cylinder. Further, said elongate central member is essentially hollow, resulting in said member having an inner bore extending therethrough. Said inner bore is oriented parallel to the longitudinal axis of said elongate central member.

One or more apertures extend through said elongate central member thereby effectively communicating the inner bore (and the inner surface) of said elongate central member with the outer surface of said elongate central member. It is conceivable that said elongate central member would take the form of a slotted liner, perforated tube or the like. However, in the preferred embodiment, said elongate central member is a cylindrical wire-wrapped screen. The gaps or spaces between the wire wrapping of such screen form an opening which allows communication from the outer surface to the inner bore/inner surface of said cylindrical screen.

Said wire-wrapped screen is positioned to receive fluids-laden drill cuttings containing entrained and/or adherent fluids on its outer surface. While said wire-wrapped screen can be positioned in any number of different locations, in the preferred embodiment said wire-wrapped screen is oriented near an outlet of a drilling rig shale shaker where fluids-laden cuttings exit said shale shaker. Said wire-wrapped screen is mounted so that its longitudinal axis is in a generally horizontal direction and transverse to the direction that fluids-laden drill cuttings exit said shale shaker.

Said wire-wrapped screen revolves or rotates about its longitudinal axis. In the preferred embodiment, a shaft is concentrically disposed within the inner bore of said cylindrical wire-wrapped screen. A plurality of baffles extend radially outward from said concentric shaft to the inner surface of said wire-wrapped screen, thereby forming a plurality of compartments within the inner bore of said wire-wrapped screen.

A pressure differential is created between the outer and inner surfaces of said cylindrical wire-wrapped screen. Said pressure differential is created by application of suction pressure into the inner bore of said cylindrical wire-wrapped screen. In the preferred embodiment, a suction housing is affixed to the ends of said cylindrical wire-wrapped screen. Said suction housings are connected to a vacuum source in order to impart suction pressure through said suction housing and into the inner bore of said cylindrical wire-wrapped screen.

Said suction housings must form pressure seals with the respective ends of said cylindrical wire-wrapped screen in order for the suction pressure to translate into the inner bore of said cylindrical wire-wrapped screen. Accordingly, the face of each suction housing which is immediately adjacent to one end of said cylindrical wire-

wrapped screen must be capable of creating a pressure seal. In the preferred embodiment, said face of each suction housing is constructed of a suitable sealing material, such as an elastomer and/or ultra-high molecular weight plastic. Additionally, said suction housings are biased against the ends of said cylindrical wire-wrapped screen to further facilitate said pressure seal.

For reasons described in detail below, it is beneficial to direct the suction toward the upper portion of said cylindrical wire-wrapped screen. Thus, communication ports are located near the upper ends of the sealing faces of said suction housings. When suction pressure is applied to said suction housings, the suction (vacuum) is transferred to the inner bore of said cylindrical wire-wrapped screen through said communication ports. However, because of said radial baffles, such suction is focused only into those internal compartment(s) which are immediately adjacent and open to the communication ports in said suction housings. Because the communication ports of each suction housing are near the top of each suction housing, application of the vacuum is therefore limited to the upper portion of said cylindrical wire-wrapped screen.

Fluids-laden drill cuttings exit the shale shaker or other separation device and are deposited on the outer surface of the cylindrical wire-wrapped screen. As suction pressure (such as from a vacuum) is applied to the inner bore of said cylindrical wire-wrapped screen, drilling mud and other fluids are separated from the solid components of said drill cuttings and pass through the opening(s) of said cylindrical wire-wrapped screen. Because the solid components of the drill cuttings are too large to pass through said openings, such solids remain on the outer surface of said cylindrical

screen. In essence, the cylindrical wire-wrapped screen serves as a filtering means to filter entrained and/or adherent fluids from said drill cuttings.

Suction pressure is specifically directed to the upper portions of said cylindrical wire-wrapped screen. Accordingly, fluid-laden drill cuttings placed upon the upper portion of the outer surface of said cylindrical screen will be exposed to suction pressure. However, as said cylindrical screen continues to rotate, suction pressure will not be transmitted to other portions of said cylindrical screen. Thus, the solid components of the cuttings which have been dried and are remaining on the outer surface of said screen will eventually roll off the face of said screen due to such rotation. In the preferred embodiment of the present invention, the speed of such rotation can be adjusted to optimize the retention time of said fluids-laden cuttings on the upper portion of the outer surface of said cylindrical wire-wrapped screen and, accordingly, the amount of exposure of said cuttings to suction pressure. Because drill cuttings from different wells, and/or drill cuttings generated by different drill bits, may consist of different types and/or sizes of solids, such drill cuttings may have different amounts of entrained and/or adherent fluids contained therein. As such, it may be desirable to adjust the rotational speed of said cylindrical wire-wrapped screen to ensure that said cuttings receive the ideal exposure to suction pressure in order to optimize fluid separation.

It is often beneficial to agitate fluids-laden drill cuttings deposited on the outer surface of said cylindrical wire-wrapped screen. In the preferred embodiment, a reciprocating scraper is positioned along the upper surface of said cylindrical wire-wrapped screen. Said reciprocating scraper moves in a path of travel parallel to the

longitudinal axis of said cylindrical wire-wrapped screen. As fluids-laden drill cuttings are deposited on the upper portion of said cylindrical wire-wrapped screen, said reciprocating scraper evens the piled cuttings, reducing the angle of repose and speeding the spreading of such cuttings over the upper surface of said cylindrical wire-wrapped screen. Said reciprocating scraper also helps to clear the surface of the cylindrical screen, thereby improving effectiveness of the fluid separation.

A brush or other cleaning apparatus is provided to clean the aperture(s) in said wire-wrapped screen. In the preferred embodiment, a brush is provided to continuously clean sediment, cuttings and/or other debris from said aperture(s) in the screen. Said brush is elongated and substantially cylindrical and mounted parallel to the longitudinal axis of said cylindrical screen. Bristles from said brush act to clean the wire-wrapped screen, and to dislodge any materials stuck in the aperture(s) of said wire-wrapped screen.

Fluid(s) separated from said drill cuttings are piped away from the inner bore of said cylindrical wire-wrapped screen. Said fluids are directed into the active mud system for re-use or, alternatively, to separate facilities for storage and/or disposal. Similarly, dried solids remaining from the drill cuttings roll off said rotating cylindrical wire-wrapped screen. Said solid components can be disposed of at the rig-site or, if preferred, collected for transportation and off-site disposal.

BRIEF DESCRIPTION OF DRAWINGS

FIGURE 1 depicts a schematic view of a mud system of a typical drilling rig which includes the present invention.

FIGURE 2 depicts a perspective view of certain components of the present invention.

FIGURE 3 depicts an exploded perspective view of the components of the present invention depicted in FIGURE 2.

FIGURE 4 depicts a perspective view of an inner face member of a suction housing of the present invention.

FIGURE 5 depicts a side view of drive shaft and baffle components of the present invention.

FIGURE 6 depicts an end view of drive shaft and baffle components of the present invention.

FIGURE 7 depicts a perspective view of the front of a preferred embodiment of the present invention.

FIGURE 8 depicts an overhead view of a preferred embodiment of the present invention.

FIGURE 9 depicts an end view of a preferred embodiment of the present invention.

FIGURE10 depicts an end view of a preferred embodiment of the present invention.

FIGURE 11 depicts a side view of the rear of a preferred embodiment of the present invention.

DETAILED DESCRIPTION OF A PREFERRED EMBODIMENT

Referring to the drawings, FIGURE 1 depicts a schematic representation of the mud system of a typical drilling rig. The flow of drilling mud within this mud system in FIGURE 1 is generally in the direction of the arrows.

Still referring to FIGURE 1, derrick 1 extends vertically over wellbore 2. Tubular work string 3 is inserted into wellbore 2, and extends from the earth's surface to a desired depth within said wellbore 2. Flow line 4a is connected to said tubular work string 3. Flow line 4b is connected to annular space 5 formed between the outer surface of tubular work string 3 and the inner surface of wellbore 2.

Still referring to FIGURE 1, the bulk of the drilling mud for the depicted mud system is in mud pit 6. Mud from said mud pit 6 is circulated through the overall mud system depicted schematically in FIGURE 1 via mud pump 7. During typical drilling operations, mud is pumped into tubular work string 3 through flow line 4a, circulated out the bottom end 3a of tubing 3, up the annulus 5 of wellbore 2, and out of said wellbore annulus 5 via flow line 4b.

During standard drilling operations, mud exiting the wellbore annulus 5 through flow line 4b often includes drill cuttings and other debris encountered in wellbore 2. Frequently, such drill cuttings are generated downhole as a result of the drilling process. Such drill cuttings and other debris would typically contaminate the overall quality of the mud system if allowed to remain in the active mud system. Accordingly, the mud and drill cuttings mixture leaving the well is directed to a separation device, such as shale shakers 8. It is to be understood that any number of separation devices could be used for this purpose; however, for purposes of illustration in FIGURE 1, said

separation device is depicted as being shale shakers 8. As the combined mixture of drilling mud and drill cuttings are directed over shale shakers 8, much of the "free" liquid mud passes through the screens of said shale shakers 8 and is directed into mud pit 6. Although such "free" liquids are separated at the shale shakers, the drill cuttings still frequently contain entrained and/or adherent fluids. These drill cuttings pass over shale shakers 8 and are thereafter discharged from said shale shakers.

For reasons described above, drill cuttings discharged from shale shakers 8 generally cannot simply be re-introduced into the active mud system and pumped back into a well. Accordingly, such drill cuttings must be treated and/or disposed of properly. In many cases, it is possible to collect such drill cuttings for transportation and eventual disposal. However, it is frequently beneficial to separate entrained and/or adherent drilling muds and other fluids from said cuttings at the drilling rig location prior to such transportation and/or disposal. In many cases, recovered mud and/or associated liquids can be introduced back into the active mud system resulting in significant cost savings. Further, disposal of solids is generally much more efficient after liquids have first been separated from such solids.

FIGURE 1 depicts the separation apparatus of the present invention, 10, installed downstream of said shale shakers 8 in schematic form. As fluid-laden drill cuttings exit shale shakers 8 and pass onto separation apparatus 10, fluids are suctioned away from the solid components of said drill cuttings and returned to mud pit 6 using vacuum 9. Depending on the drilling environment in question, fluids other than drilling mud may be recovered in this process. Accordingly, although not specifically depicted in FIGURE 1, it is possible to include additional separation means to remove

contaminants and/or other fluids from the recovered drilling mud prior to returning such mud to the bulk mud system in mud pit 6. Additionally, although separation apparatus 10 is depicted as being distinct from shale shakers 8, in certain situations separation apparatus 10 could be installed within the body of shale shakers 8 or at some other desirable location.

Dried solids, typically comprised of drilled-up pieces of rock and other debris originating from wellbore 2, advance over separation apparatus 10. Such solids can be directed to collection box 30 for storage or eventual transportation to an off-site disposal facility. Alternatively, depending upon environmental and/or other regulatory issues, said dried cuttings can often be disposed of on site. For example, assuming applicable regulations are satisfied, such dried cuttings may be disposed of or released directly into the surrounding environment.

FIGURE 2 depicts a perspective view of certain components of the preferred embodiment of the fluid separation apparatus 10 of the present invention. Substantially cylindrical wire-wrapped screen 11 is positioned so that its longitudinal axis is oriented in a generally horizontal direction. (As discussed above, it is possible that another substantially hollow, cylindrical member could be used instead of cylindrical wire-wrapped screen 11, such as, for example, a slotted or perforated tube). Cylindrical wire-wrapped screen 11 is substantially hollow; drive shaft 12 is concentrically disposed within the longitudinal bore of said cylindrical screen 11. Suction housing 13, having outlet line 14, is installed on at least one end of said cylindrical wire-wrapped screen 11. Re-sealable port 13a provides access to the inside of suction housing 13 for cleaning and/or other needs that may arise. (Suction housing 13 is shown in FIGURE 2 as being

installed only on one end of cylindrical wire-wrapped screen 11. However, it is to be understood that in the preferred embodiment suction housings 13 are installed at each end of said cylindrical wire-wrapped screen 11.) Scraper member 20 is slidably disposed along the upper portion of the outer surface of cylindrical wire-wrapped screen 11.

FIGURE 3 depicts an exploded perspective view of the components of the preferred embodiment of the present invention illustrated in FIGURE 2. Horizontally oriented drive shaft 12 is concentrically disposed within the longitudinal bore of hollow cylindrical wire-wrapped screen 11. Bushing 16 is mounted on said drive shaft. A plurality of baffles 15 extend radially outward from said bushing 16 and drive shaft 12. Baffles 15 extend outward from said bushing to the inner surface of said cylindrical wire-wrapped screen 11 and create a plurality of generally wedge-shaped compartments within said cylindrical wire-wrapped screen 11.

Suction housing 13 is received on drive shaft 12 and is positioned immediately adjacent to a lateral end of cylindrical wire-wrapped screen 11. Re-sealable port 13a provides access to the inside of suction housing 13. Outlet line 14 extends from said suction housing 13. In the preferred embodiment of the present invention, outlet line 14 has a barb fitting or threads for connection with a hose or flow line (not shown). For illustration purposes, a single suction housing 13 is depicted in FIGURE 3. However, it is to be understood that suction housings are installed at both ends of cylindrical wire-wrapped screen 11 in the preferred embodiment of the present invention.

Inner face member 40 of suction housing 13 is ideally constructed of sealable material. When suction housing13 is installed on drive shaft 12, inner face member 40

of suction housing 13 forms a pressure seal with terminal edges 15a of baffles 15. This pressure seal remains intact even while cylindrical wire-wrapped screen 11 is rotated. Although any number of non-abrasive materials can be used for providing such a pressure seal, in the preferred embodiment of the present invention inner face member 40 of suction housing 13 is constructed of a durable elastomer such as ultra high molecular weight plastic or the like. In order to facilitate this pressure seal, compression spring 17 and lock-down bracket 18 can be used to bias suction housing 13 and, thus, inner face member 40 of said suction housing 13, against terminal edges 15a of baffles 15. Inner face member 40 of suction housing 13 has first opening 41 to permit pressure communication between suction housing 13 and selected compartments within the inner bore of cylindrical wire-wrapped screen 11.

Scraper member 20 is generally disposed along the upper surface of cylindrical wire-wrapped screen 11. In the preferred embodiment of the present invention, scraper member 20 comprises substantially parallel end plates 21 and 22. End plate 22 includes a concave or curved internal edge 22a having a radius of curvature that is slightly larger than that of cylindrical wire-wrapped screen 11. End plate 21 likewise includes a curved internal edge (obscured from view in FIGURE 3) which is similar to internal edge 22a. Apron plate 23 extends between end plates 21 and 22, and forms a trough-like surface between said end plates. A plurality of intermediate and substantially parallel plate members 24 are disposed between end plates 21 and 22 at desired intervals along the length of scraper member 20. Said intermediate plate members 24 also have concave or curved internal edges 24a which have a radius of curvature that is slightly larger than that of cylindrical wire-wrapped screen 11. Said

intermediate plate members 24 also include communication bores 25, and are anchored in place with anchor strip 26.

FIGURE 4 depicts inner face member 40 of a suction housing 13. Said inner face member 40 is a substantially round and substantially planar element. Said inner face member must form a pressure seal against terminal edges 15a of baffles 15. Accordingly, in the preferred embodiment, said inner face member 40 is constructed of ultra high molecular weight plastic, elastomer or other sealing material. First opening 41 extends through said inner face member 40; in the preferred embodiment, said first opening 41 is generally wedge-shaped and, when installed, is oriented near the upper portion of cylindrical wire-wrapped screen 11.

Inner face member 40 also includes central bore 42 for receiving drive shaft 12.. Said inner face member 40 is disposed on said drive shaft 12 between a suction housing 13 and one end of said cylindrical wire-wrapped screen 11. Said inner face member 40 also includes second opening 43. In the preferred embodiment, said second opening 43 is ideally smaller than first opening 41 and is oriented opposite near the bottom of cylindrical wire-wrapped screen 11.

FIGURE 5 is a side view of drive shaft 12 and baffles 15 of the present invention. Drive shaft 12 is a substantially cylindrical elongate member. Bushings 16 are received on drive shaft 12. Baffles 15 extend radically outward from said bushings 16. Ramp members 19 begin near bushings 16 toward each end of drive shaft 12 and extend upward at an inclined angle toward the mid-point of said baffles thereby forming peak 19a. FIGURE 6 depicts an end view of drive shaft 12 and baffles 15 of the present invention. Bushing 16 is received on drive shaft 12, and baffles 15 extend radially

outward from said bushing. Ramp members 19 each begin near said bushing, and extend upward at an inclined angle, reaching peak 19a near the mid-point and outer edges of baffles 15.

FIGURE 7 depicts a perspective view of the front of a preferred embodiment of the fluid separation apparatus 10 of the present invention. Substantially cylindrical wire-wrapped screen 11 is positioned so that its longitudinal axis is oriented in a generally horizontal direction. Although not shown in FIGURE 7, cylindrical wire-wrapped screen 11 is substantially hollow, and drive shaft 12 is concentrically disposed within the longitudinal bore of said cylindrical screen 11. Suction housings 13, having outlet lines 14, are installed at both ends of said cylindrical wire-wrapped screen 11. Re-sealable cleaning port 13a permits access to the inside of suction housing 13. Scraper member 20 is slidably disposed along the upper surface of cylindrical wire-wrapped screen 11.

Scraper member 20 is generally comprised of substantially parallel end plates 21 and 22. A plurality of intermediate plate members 24 are disposed between end plates 21 and 22 at desired intervals between end plates 21 and 22 along scraper member 20. Said intermediate plate members 24 also include communication bores 25 to permit transfer of solid cuttings and liquids between voids formed by said intermediate plate members 24. In the preferred embodiment, said intermediate plate members are anchored to one another with anchor strip 26. In the preferred embodiment, the apparatus of the present invention is included within frame 27, which promotes ease of transportation and installation of said apparatus on a drilling rig location.

Elongate brush 50 is disposed along one face of separation apparatus 10. In the preferred embodiment, said brush is an elongate, substantially cylindrical brush which is

oriented generally parallel to said cylindrical wire-wrapped screen 11. Brush 50 comprises central shaft 51 which is rotatably mounted in end mounts 52 of adjustable arms 53. Brush 50 can be raised and lowered relative to cylindrical wire-wrapped screen 11 using adjustable arms 53. Further, said brush 50 can be rotated about its longitudinal axis using adjustable speed brush motor 54. Brush 50 can also be biased against cylindrical wire-wrapped screen 11 using adjustable tensioners 55.

Rotation of cylindrical wire-wrapped screen 11 about its longitudinal axis is driven by screen drive motor 60. One end of drive shaft 12 of wire-wrapped screen 11 is rotatably received within bearing mount 61, while the other end of said drive shaft 12 is rotatably mounted using worm gear 62. Reciprocation of scraper member 20 is powered by scraper motor 28 and eccentric disk member 29 (partially obscured from view in FIGURE 7). Scraper arm 31 is connected to scraper member 20 using mounting bracket 32.

FIGURE 8 depicts an overhead view of a preferred embodiment of the present invention. Cylindrical wire-wrapped screen 11 is mounted in a substantially horizontal orientation within frame 27. Drive shaft 12 is mounted at one end within worm gear 62. The other end of drive shaft 12 is mounted within bearing mount 61 (not shown in FIGURE 8). Screen drive motor 60 is attached to worm gear 62 and powers rotation of cylindrical wire-wrapped screen 11 about its longitudinal axis. Suction housings 13 having outlets 14 are disposed on each end of said cylindrical wire-wrapped screen 11.

Brush 50 is disposed along one face of cylindrical wire-wrapped screen 11. Said brush 50 is comprised of central elongate shaft 51 which is rotatably mounted within end mounts 52. Rotation of central shaft 51, and thus brush 50, is powered by brush

motor 54. The vertical position of brush 50 relative to wire-wrapped screen 11 can be adjusted using adjustable arms 53. Brush 50 can also be biased against cylindrical wire-wrapped screen 11 using adjustable tensioners 55. Because said tensioners are adjustable, the pressure that brush 50 exerts against the surface of cylindrical wire-wrapped screen 11 can be varied as desired.

Scraper member 20 comprised of end plates 21 and 22, as well as intermediate plate members 24, is disposed on the upper surface of cylindrical wire-wrapped screen 11. Apron plate 23 extends between said end plates 21 and 22. Anchor strip 26 is affixed to the upper surface of said intermediate plate members 24.

FIGURES 9 and 10 depict end views of opposite ends of a preferred embodiment of the present invention. Cylindrical wire-wrapped screen 11 is mounted in a substantially horizontal orientation. One end of drive shaft 12 of cylindrical wire-wrapped screen 11 is mounted using worm gear 62 (FIGURE 9), while the other end of said drive shaft 12 is mounted within bearing mount 61 (FIGURE 10). Referring to FIGURE 9, screen drive motor 60 is attached to worm gear 62 and powers rotation of drive shaft 12 and, ultimately, cylindrical wire-wrapped screen 11. Scraper member 20 having end plate 22 (FIGURE 9) and end plate 21 (FIGURE 10) is mounted along the upper surface of cylindrical wire-wrapped screen 11.

Brush 50 is disposed along the front face of cylindrical wire-wrapped screen 11. The relative height of brush 50 can be varied using adjustable arms 53. Rotation of said brush 50 is powered, via central shaft 51, using brush drive motor 54 (FIGURE 9).

Referring to FIGURE 10, scraper motor 28 drives eccentric disk member 29. One end of scraper arm 31 is attached to eccentric disk member 29, while the other

end of scraper arm 31 is attached to scraper mounting bracket 32. Scraper mounting bracket 32 is in turn attached to scraper member 20. FIGURE 11 depicts scraper arm 31 attached to eccentric disk member 29 at one end, and scraper mounting bracket 32 at the other end. Scraper motor 28 powers rotation of eccentric disk member 29, which in turn causes scraper member 20 to reciprocate back and forth along the upper surface of wire-wrapped screen 11.

Still referring to FIGURE 11, upper scraper brackets 70 are attached along the length of scraper member 20. Shafts 71 extend upward from said upper scraper brackets 70. Nuts 72 are in turn mounted on said shafts 71, and provide a base for biasing springs 73 which are located between washers 76. Said shafts 71 extend through slotted base plates 74 which are attached to fixed frame 27. Referring to FIGURE 8, shafts 71 are shown extending through slots 74a in base plates 74. Sliding plates 75 are also mounted on shafts 71 and held in place on the upper surface of base plates 74 using nuts 76 and washers 77. In the preferred embodiment, sliding plates 75 are constructed of plastic, teflon or some friction reducing yet durable material.

Scraper motor 28 causes eccentric disk 29 to rotate, which in turn causes scraper arm 31 to reciprocate back and forth. Scraper arm 31, which is mounted to scraper member 31 using scraper mounting bracket 32, in turn causes scraper member 20 to reciprocate in a generally horizontal direction along the upper surface of cylindrical wire-wrapped screen 11. As scraper member 20 reciprocates, shafts 71 ride back and forth within slots 74a of base plates 74. Scraper 20 is thereby supported and guided by sliding plates 75 which ride back and forth within the channels formed by the upper surface of base plates 74.

In operation, fluids-laden drill cuttings are deposited (typically from a rig's shale shaker) on the trough-like surface formed by apron plate 23 of scraper member 20 and/or, ultimately, onto upper exterior surface of cylindrical wire-wrapped screen 11. As a vacuum is applied to outlet lines 14 of suction housings 13, suction pressure is communicated to the inner bore of said cylindrical wire-wrapped screen 11 and, more specifically, to the upper portion of same. Such suction pressure is ultimately applied to fluid-laden drill cuttings deposited on the outer surface of cylindrical wire-wrapped screen11 via aperture(s) extending through said screen.

Drilling mud and other fluids separate from the solid components of said drill cuttings and pass through the aperture(s) of said cylindrical wire-wrapped screen 11. Because the solid components of the drill cuttings are too large to pass through said aperture(s), such solids remain on the outer surface of said cylindrical screen 11. Said cylindrical wire-wrapped screen 11 serves as a filtering means to filter entrained and/or adherent fluids which are suctioned from said drill cuttings.

Suction pressure is specifically directed to and focused on the upper portions of said cylindrical wire-wrapped screen 11 where fluids-laden cuttings are deposited. When suction pressure is applied to said suction housings 13, the pressure drop (vacuum) is transferred to the inner bore of said cylindrical wire-wrapped screen 11 via first openings 41 of said suction housings 13 (shown most clearly in FIGURE 3). However, because of radial baffles 15, such suction pressure is focused into only those internal compartment(s) within the inner bore of cylindrical wire-wrapped screen 11 which are immediately adjacent to and in communication with first openings 41 in said suction housings 13. Further, because first openings 41 of suction housings 13 are

beneficially positioned near the upper portion of said suction housings 13 and inner face members 40, application of the vacuum is therefor primarily focused to the upper portion of said cylindrical wire-wrapped screen 11. Accordingly, fluid-laden drill cuttings placed upon the upper portion of the outer surface of said cylindrical wire-wrapped screen 11 will be exposed to suction pressure, while cuttings or debris remaining on other portions of said cylindrical wire-wrapped screen 11 will not be exposed to such suction pressure.

As drive shaft 12 rotates and cylindrical wire-wrapped screen 11 is rotated about its longitudinal axis, suction pressure will not be transmitted to other portions of said cylindrical screen which are not in pressure communication with suction housings 13. Thus, any solid components of drill cuttings which have previously been separated from entrained and/or adherent fluids, but are remaining on the outer surface of said cylindrical wire-wrapped screen, will not be exposed to suction pressure and will eventually roll off the outer surface of said cylindrical wire-wrapped screen due to such rotation. Brush 50 also assists in removal of solids from the face of cylindrical wire-wrapped screen 11, as well as removal of any solids or particulate matter from the apertures of said screen 11.

In the preferred embodiment of the present invention, the rotational speed of cylindrical wire-wrapped screen 11 can be adjusted to optimize the retention time of fluids-laden drill cuttings on the upper portion of the outer surface of said cylindrical wire-wrapped screen 11and, accordingly, the amount of exposure of said cuttings to suction pressure. Because drill cuttings from different wells, and/or drill cuttings generated by different drill bits, may include different types and/or sizes of solids, such

drill cuttings may have different amounts of entrained and/or adherent fluids contained therein. As such, it may be desirable to adjust the rotational speed of said cylindrical wire-wrapped screen 11 to ensure that said cuttings receive the ideal exposure to suction pressure in order to optimize fluid separation.

It is often beneficial to agitate fluids-laden drill cuttings deposited on the outer surface of said cylindrical wire-wrapped screen 11. In the preferred embodiment, reciprocating scraper member 20 is positioned along the upper surface of said cylindrical wire-wrapped screen 11. Said reciprocating scraper moves in a path of travel parallel to the longitudinal axis of said cylindrical wire-wrapped screen 11. As fluids-laden drill cuttings are deposited on the trough-like surface formed by apron plate 23 and/or the upper portion of said cylindrical wire-wrapped screen 11, said reciprocating scraper member 20 evens the piled cuttings, reducing the angle of repose and speeding the spreading of such cuttings over the upper surface of said cylindrical wire-wrapped screen 11. Said reciprocating scraper member 20 also helps to clean the surface of the cylindrical screen 11, thereby improving effectiveness of the fluid separation process. Intermediate plate members 24 of scraper member 20 help to break up and/or evenly distribute such deposited cuttings. Communication bores 25 in intermediate plate members 24 permit piled cuttings to pass between said intermediate plate members to help facilitate even distribution of deposited drill cuttings on the upper surface of cylindrical wire-wrapped screen 11.

Suctioned fluids separated from the solid components of drill cuttings are piped away from the inner bore of said cylindrical wire-wrapped screen 11. Said fluids enter the segmented compartments within the inner bore of wire-wrapped screen 11 formed

by radial baffles 15, and pass (via first openings 40) into suction housings 13. Said fluids are evacuated from suction housings 13 via outlet lines 14 and ultimately directed into the active mud system for re-use or, alternatively, to separate facilities for storage and/or disposal. Similarly, dried solids remaining on the outer surface of cylindrical wire-wrapped screen 11 from the previously fluid-laden drill cuttings will generally roll off said rotating cylindrical wire-wrapped screen. Said solid components can be disposed of at the drill site or, if preferred, collected for transportation and off-site disposal.

Although preferred embodiments of the subject invention have been described herein, it should be understood that various changes, adaptations and modifications may be made therein without departing from the spirit of the invention and the scope of the appended claims.